Team

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Hardware Guru
Device Design, Assembly
PCB Design, & Power

Chad Klinefelter, CSE
Backend Guru
Data Management &
App Development

Jackie Lagasse, CSE
UI/UX Guru
Augmented Reality &
App Development

Ethan Miller, EE
Algorithms Guru
Device Communication &
Sensor Interfacing

Department of Electrical and Computer Engineering

Advisor: Professor Holcomb
**Problem Statement**

- AR users are unable to incorporate extremities into an interactive application unless their device camera can directly face them.
- There are no inertial sensing products for extremity tracking that can be used in AR applications.

**Solution: a separate foot attachment**

- Sensor on foot can transmit data to phone, where it can then be acted upon.
Our Vision

On demo day we plan to present the following:

- Bring user to an open space
- User wears headset and kick tracker
- Start ARK app on phone
- App displays virtual soccer ball and goal
- User kicks foot, observes movement of soccer ball
## System Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>App connects to Bluetooth and begins game in less than 10 seconds</td>
<td>Met - 2-5 seconds on average</td>
</tr>
<tr>
<td>App must determine user’s kick speed and direction</td>
<td>Met - Straight, Angle, 90 deg kicks implemented</td>
</tr>
<tr>
<td>Ball must move with speed and direction proportional to user’s foot</td>
<td>Met - Unity game engine maps input vectors to ball as a rigid body</td>
</tr>
<tr>
<td>System delay &lt; 300ms, ideally &lt;100ms</td>
<td>Met - 18.7 Hz from sensor to Unity, 60 Hz refresh, 5 frames = 83ms delay</td>
</tr>
<tr>
<td>Maximum dimensions of device: 4 x 3 x 2 inches</td>
<td>Met - 4.5 x 3 x 1.25 - overall volume is within spec</td>
</tr>
<tr>
<td>Maximum weight: 1 lb</td>
<td>Met - Weight 4.6oz less than 1/3 of spec)</td>
</tr>
<tr>
<td>Minimum battery life: 5 hours</td>
<td>Met - Sources ~65mA during operation = 46hr of battery life</td>
</tr>
</tbody>
</table>
Block Diagram

Kick Tracker

- MPU-6050 Sensor
- ATMega32 Microcontroller
- 5V Voltage Regulator
- HC-05 Bluetooth Module
- 3.7V LiPo Battery

Smartphone

- Data Analysis
- Unity 3D
  - Kick Detection
  - Sensor Database
  - User Score
- User Interface
  - ARCore
    - Display Soccer Net
    - Display Ball Movement
    - Display User Score

Transmit raw sensor data over Bluetooth to smartphone's terminal.

All components in kick tracker are connected together in PCB. Battery is rechargeable.

User data consists of user's score in this play through.
# FPR Deliverables Status

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Member</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware:</strong> Assemble final case along with new PCB for more efficient layout</td>
<td>Matteo</td>
<td>Completed</td>
</tr>
<tr>
<td><strong>Backend:</strong> Finish implementing sensor data storage system and refine data storage as kick model is finalized</td>
<td>Chad</td>
<td>Completed</td>
</tr>
<tr>
<td><strong>Algorithms:</strong> Implement algorithms for at least 2 different kick types and refine thresholds to optimize kick detection for a variety of users</td>
<td>Ethan</td>
<td>Completed</td>
</tr>
<tr>
<td><strong>Update UI:</strong> Implement left and right foot calibration and improve user interface</td>
<td>Jackie</td>
<td>Completed</td>
</tr>
</tbody>
</table>
PCB Layout

- Both PCB designs are complete and work properly
- New PCB layout is almost \( \frac{1}{3} \) size of old board
- Same width, significantly smaller length
- Better fit for shoes
Enclosure

- Current Dimensions:
  - Length - 3”
  - Width - 4.5”
  - Height - 1.25”
  - Thickness - 0.125”

- Material: 3D Solutech (White) Polylactic Acid
Sensor Data / Storage

- Caching recent most ~300 ms (5 samples) of data
  - Get kick peaks with reduced noise by averaging last 5 samples
- **User delay: 83 ms**
  - Data rate: 18.7 Hz (data update every 54 ms)
    - Upon each data update, assume we have 4 previous samples as well
  - Frame rate: 60 Hz (frame update every 17 ms)
  - **Delay: 4 frames for data arrival + 1 frame for processing = 83 ms**
Kick Detection

- Extracted features from time series via MATLAB
  - Each axis (X,Y,Z) has a defined range for each kick type
  - Sample must concurrently fall within each axis’ range for kick to register
- Implemented in-game via a conditional assignment (easy to process)
Example Measurements

- Raw time series is averaged over a window of last 5 samples to reduce noise and peakiness
- Graph shown on right consists of 30 straight kicks, 30 kicks at 45°, and 20 kicks at 90°
App Developments

**Deliverables:**
Cleaned up menu interface
Implemented left and right foot swap

**Additional Features:**
Can easily toggle hidden debugging features
Added game timer
Added scoreboard
Can email your score
Locked screen rotation
## Budget & Cost Analysis: Production Cost

<table>
<thead>
<tr>
<th>Items Per Device</th>
<th>#</th>
<th>Bulk Cost at Bulk Quantity</th>
<th>Distributor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATMega32</td>
<td>1</td>
<td>$4.80 @ 100</td>
<td>Digikey</td>
</tr>
<tr>
<td>HC-05 Bluetooth</td>
<td>1</td>
<td>$2.75 @ 1</td>
<td>Alibaba</td>
</tr>
<tr>
<td>MPU6050 Inertial Sensor</td>
<td>1</td>
<td>$4.07 @ 1000</td>
<td>Digikey</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>1</td>
<td>$3.49 @ 100</td>
<td>Pololu</td>
</tr>
<tr>
<td>Battery</td>
<td>1</td>
<td>$3.25 @ 4</td>
<td>Amazon</td>
</tr>
<tr>
<td>PCB &amp; Case</td>
<td>1</td>
<td>$6.00</td>
<td>Estimation</td>
</tr>
<tr>
<td>Starlight Headset</td>
<td>1</td>
<td>$13.99 @ 1</td>
<td>Amazon</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>$38.05</strong></td>
<td></td>
</tr>
</tbody>
</table>

1. Device is only $24.06 if user has their own headset.

2. We have approximately $100 left of our $500 total prototyping budget.
Thank You!

Questions?